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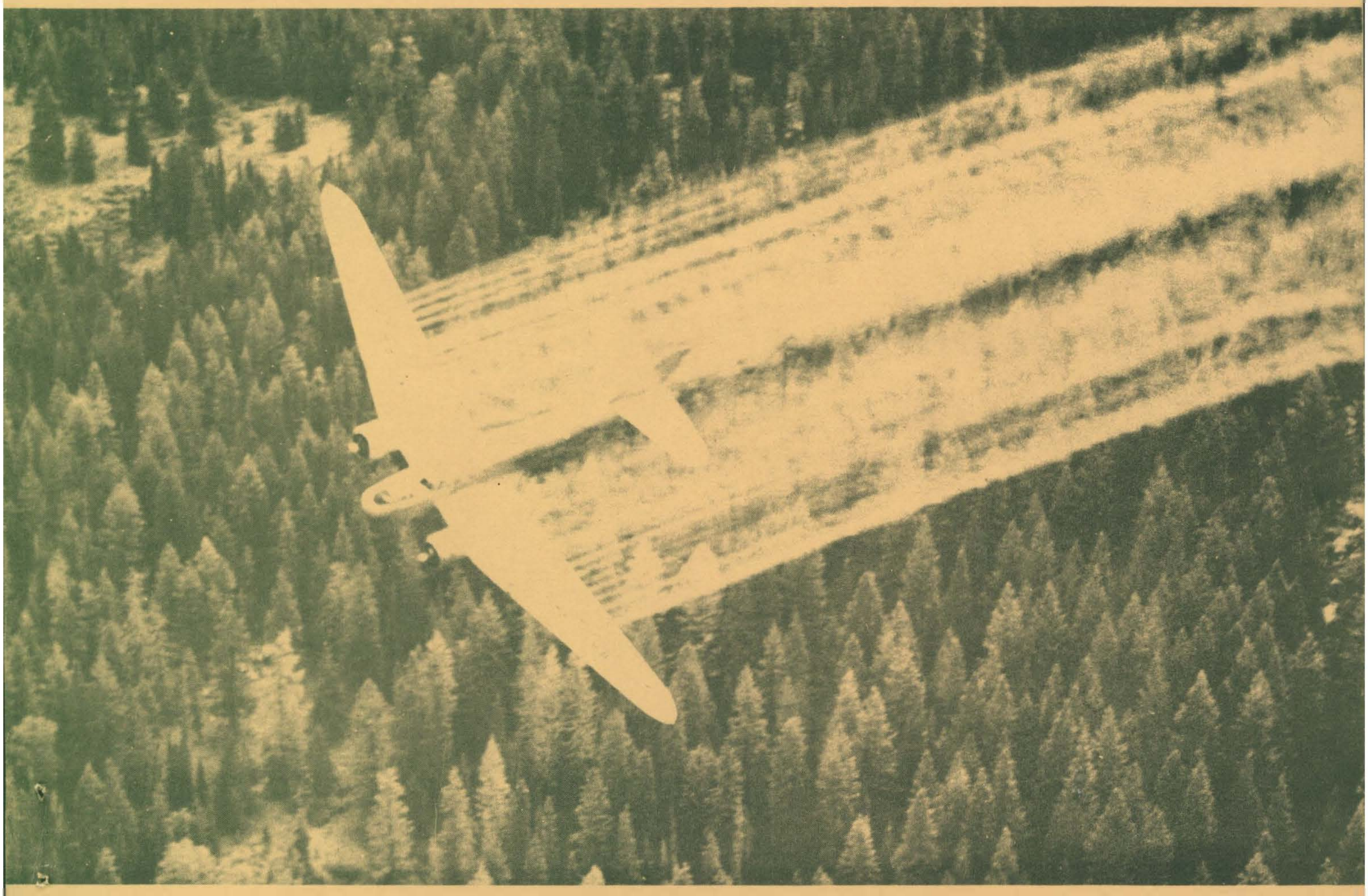
ENTOMOLOGICAL ASPECTS OF THE 1955 SOUTHERN IDAHO SPRUCE BUDWORM CONTROL PROJECT.



INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
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ENTOMOLOGICAL ASPECTS OF THE 1955 SPRUCE BUDWORM CONTROL PROJECT IN SOUTHERN IDAHO

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INTRODUCTION

The first large-scale spruce budworm control project in southern Idaho was undertaken in 1955. 893,212 acres of forest land were sprayed between July 7 and August 13 (fig. 1). An average of 95 percent mortality was achieved at a very favorable cost of 87 cents per acre.

The infestation varied greatly in its intensity and duration. In areas where heavy larval feeding had taken place for as long as 3 to 5 years, some young trees had died. Top killing of pole stands and young merchantable trees was common in many localities. It appears that such damage has been halted by the effects of the spraying.

The control project was comprised of the following units:

Unit 1	Idaho City	228,669 acres
Unit 2	Warm Springs	234,088 "
Unit 3	Cascade	158,658 "
Unit 4	McCall	271,797 "
		893,212 "

Units 1 to 3 were located on the Boise National Forest while Unit 4 included parts of the Payette National Forest and Nezperce National Forest.

The operational phase of the control project was carried out by personnel of Region 4 and technical supervision was provided by the Intermountain Forest and Range Experiment Station. A report of control operations has been prepared by National Forest Administration.[1/]

The method of control and the technical organization used during previous projects in Oregon were adopted for use. A plan[2/] for the technical supervision of one Oregon project provided guide lines for the sampling of larval development, spray deposit, and larval mortality.

1/ Spruce Budworm Control. Southwest Idaho. U. S. Dept. of Agriculture, Forest Service. Region 4. 30 pp., illus. 1955 (Multilith).

2/ Plan for the Technical Direction of the 1953 Oregon Spruce Budworm Control Project, by J. M. Whiteside. Forest Insect Laboratory, Portland, Ore. April 15, 1953. Mimeo. 16 pp.

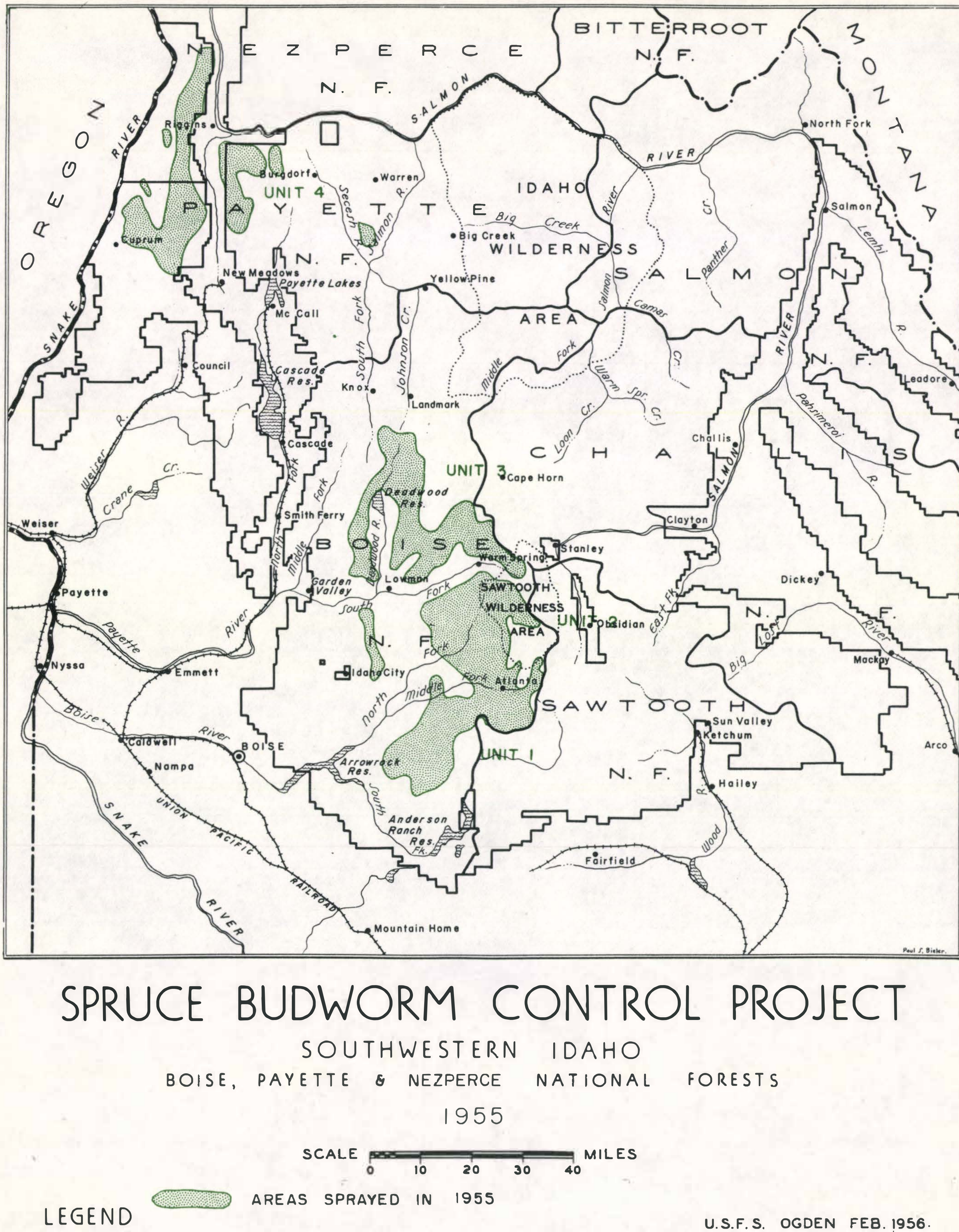


Figure 1.--A map showing the location of areas sprayed to control the spruce budworm in 1955.

For the most part the procedure worked well, but as a result of experience gained on the project, improvements in the entomological phases of future spruce budworm spray projects in the Intermountain region appear possible.

INSECT DEVELOPMENT

Some 80,000 spruce budworm larvae were collected during the daily sampling of development for the purpose of determining the proper time of spraying. The sampling began on June 13, 6 days after the 2nd instar larvae were found to have broken hibernation. Sampling was continued until July 25, at which time all spray blocks had been released for spraying.

Determination of the date of spraying in each spray block depended upon the proportion of larvae in the various instars. Spraying was most effective when all the larvae were in the 4th, 5th, and 6th instars (fig. 2). At that time the foliage usually was well developed and the maximum number of larvae were exposed to the spray.

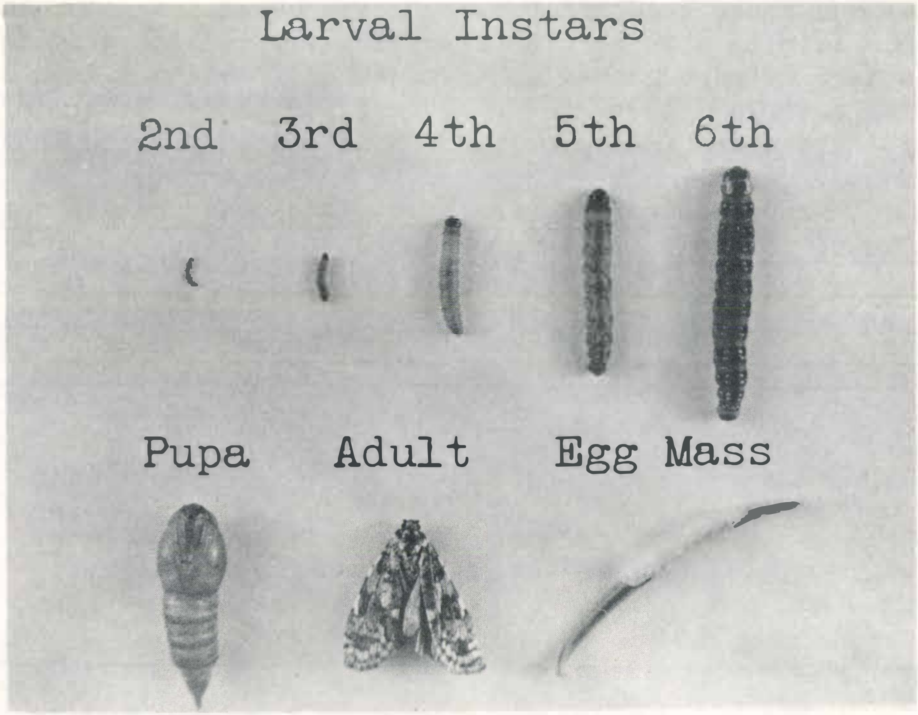


Figure 2.--Developmental stages of the spruce budworm. Spraying was done at a time when all larvae were in the last three instars.

During the latter part of the project, temperatures were high and the rate of larval development was at a maximum. A delay in spraying would have permitted too many larvae to pupate and escape the effects of the spray. This circumstance made it necessary to spray any particular spray block within a period of a few days.

The method used to obtain development samples is explained in the plan[3] for the technical direction of the project. Two types of development samples were used: One of these consisted of repeated collections of approximately 100 larvae from established sampling stations. The stations were located at 500-foot or 1000-foot intervals; the other type of sample involved the collection of approximately 50 larvae and was termed a "spot check." Spot checks were used to bolster the development information obtained from the regular sampling stations. The need for such information was greatest in the more inaccessible spray blocks and at high elevations during the first part of the project.

Larvae were segregated into instars by visual comparison with larval instar standards. The standards consisted of representative larvae which were preserved in alcohol. Certain larvae were difficult to segregate and their head widths were measured with a binocular microscope containing a micrometer disc with a 1-cm line graduated into 100 parts. Average head-width measurements are contained in table 1. The upper and lower range of each instar was determined arbitrarily. There was some overlap of head widths between instars.

Table 1.--Spruce budworm larval head-width measurements for various instars

Instar	Av. width of head capsule	Range Lower	Range Upper
	mm.	mm.	
2	0.35	-	0.42
3	.48	0.43	.62
4	.76	.63	1.01
5	1.26	1.02	1.64
6	2.02	1.65	-

3/ Plan for the Technical Direction of the 1955 Spruce Budworm Control Project in Southern Idaho, by Malcolm M. Furniss. April 14, 1955. Intermountain Forest & Range Experiment Station, Ogden, Utah. 12 pp. Mimeo.

Problems

Several problems arose during the determination of larval development. These are briefly discussed because they may be encountered on similar projects.

Because larval growth was rapid, daily collections were necessary. The samples were obtained in the field and transported to the biologist for measurement in the same day. The procurement of a sample was often a long day's work. Several hours of additional time were required to deliver the sample to the biologist or for a courier to round up all samples. Unless special arrangements were made, this task lead to difficulties.

Development was uneven between tree species in the same locality. Generally, insect development was much slower on Douglas-fir and Engelmann spruce as compared with white fir and alpine fir. This situation affected the development samples in areas where several host species were present. The problem became that of scheduling a single spraying at a time when larval development was satisfactory on all tree species in one area.

Also, some samples included larvae which were not spruce budworm. It was determined that in all cases such larvae were not numerous enough to be significant.

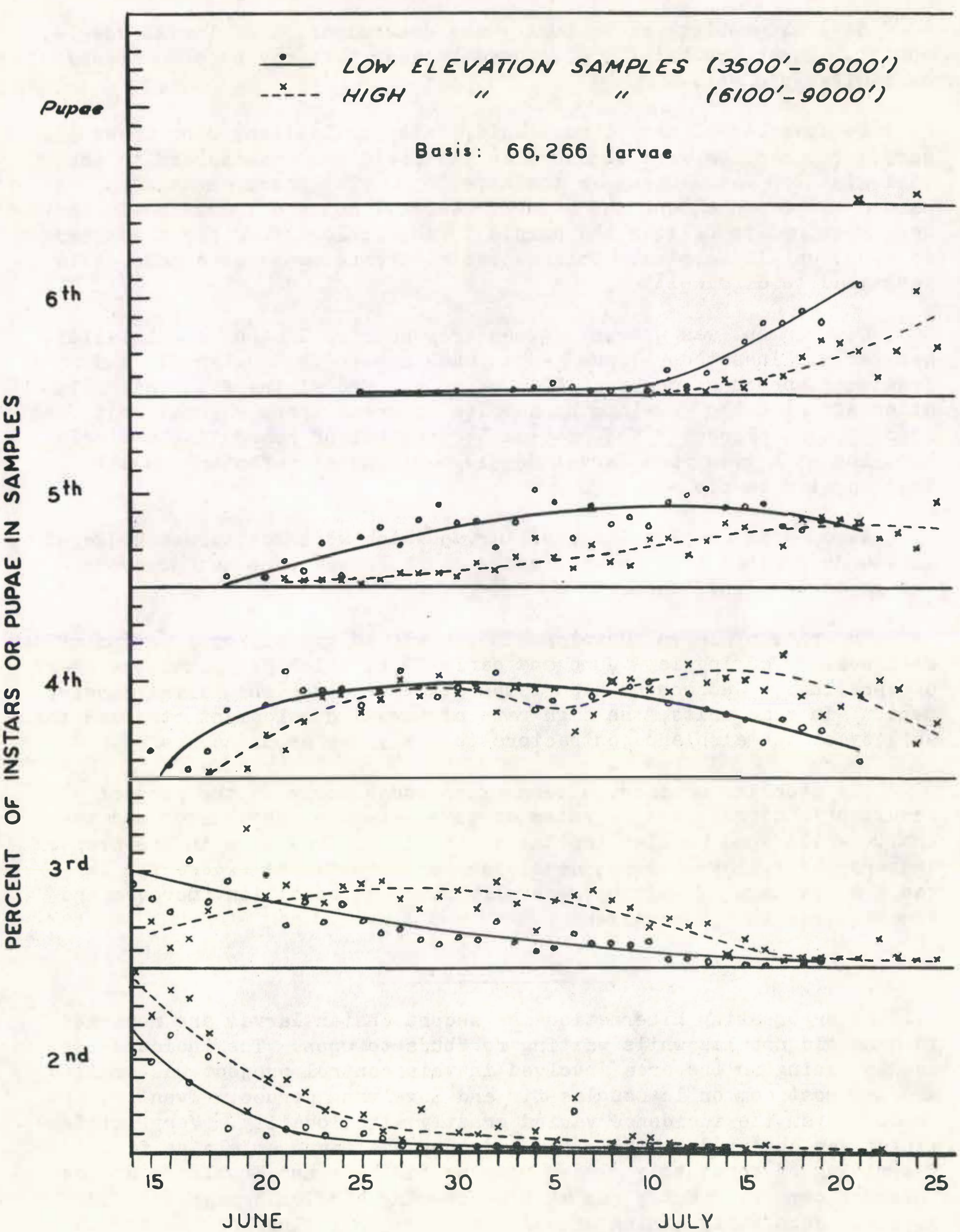
The rate of larval development was slowed greatly by a period of cool weather during late June and early July, which postponed the start of spraying. Subsequent high temperatures speeded the larval development. In some units, the high rate of larval development strained the ability of the airplane contractors to spray the areas as needed.

The peculiar weather pattern experienced early in the project resulted in differences in rates of development of the insect and the host. While some samples indicated that the larvae were in the proper instars the foliage had not developed sufficiently to expose the larvae. A few days of waiting generally saw this condition improved and spraying was then undertaken.

Observations

After breaking hibernation the second instar larvae are reported to mine old needles while waiting for buds to open. The incidence of needle mining in the area involved in this control project was small and was most common in Douglas-fir and Engelmann spruce. Even in those hosts, the incidence varied greatly with locality. Very little mining was observed on white fir and none was found on alpine fir. The mining of completely closed Douglas-fir buds and Engelmann spruce buds was common. Entry was made by chewing a hole through the bud sheath. Such early mining of buds resulted in failure of the bud to

Figure 3. **Progress of spruce budworm development during 1955 control project in southern Idaho.**



develop and it is assumed that the larvae sought new buds for food. The tendency for a large proportion of the 2nd instar larvae to attack unexpanded buds resulted in greater total defoliation than would have occurred had most of them mined needles while waiting for a bud to open. Observations suggested that after a terminal was sufficiently well developed, its foliage would support a budworm larva to maturity.

Because temperatures were lower at higher altitudes, larval development lagged as elevation increased. It was found in practice that larval development was sufficiently uniform for spraying within blocks throughout an elevational range up to 2,000 feet. The utilization of this information in defining block boundaries should materially reduce the need for "splitting" blocks, which sometimes became necessary where extreme elevational changes existed within a spray block.

Within a spray block, the effect of aspect ordinarily was not strongly reflected in the development samples. Apparently the temperature of the air mass flowing through the drainage was a more important factor than aspect. Samples obtained from ridges were sometimes more advanced than those taken in the draws which might indicate that the larvae in a more exposed position on the ridge received more direct sunlight and developed faster on that account.

Figure 3 shows the relationship between calendar date and percent of larval instars obtained in development collections. The graph was constructed from samples consisting of a total of 66,262 larvae. Data were plotted separately for low and high elevations. The curves show that a lag in development existed in the upper elevations as compared to the warmer lower elevations. The low elevation samples were obtained between 3,500 and 6,000 feet. The high elevation samples came from locations varying between 6,100 feet and approximately 9,000 feet. It is possible that a curve of this type when compared with a curve derived from nonparasitized larvae, would reveal the importance of parasitism in the area sampled. The presence of parasitism would have the apparent effect of holding development at something of a standstill for a time.

SPRAY DEPOSIT

Spray deposit was sampled throughout the project by means of cards coated with oil-sensitive dye (fig. 4). The red dye on the cards turned to a lighter color when contacted by the spray. Examination of the exposed cards enabled a determination of the size and distribution of spray droplets as well as the rate of application. The cards were placed 5 chains apart at right angles to the spray swaths; ten cards were used per line in each spray block.

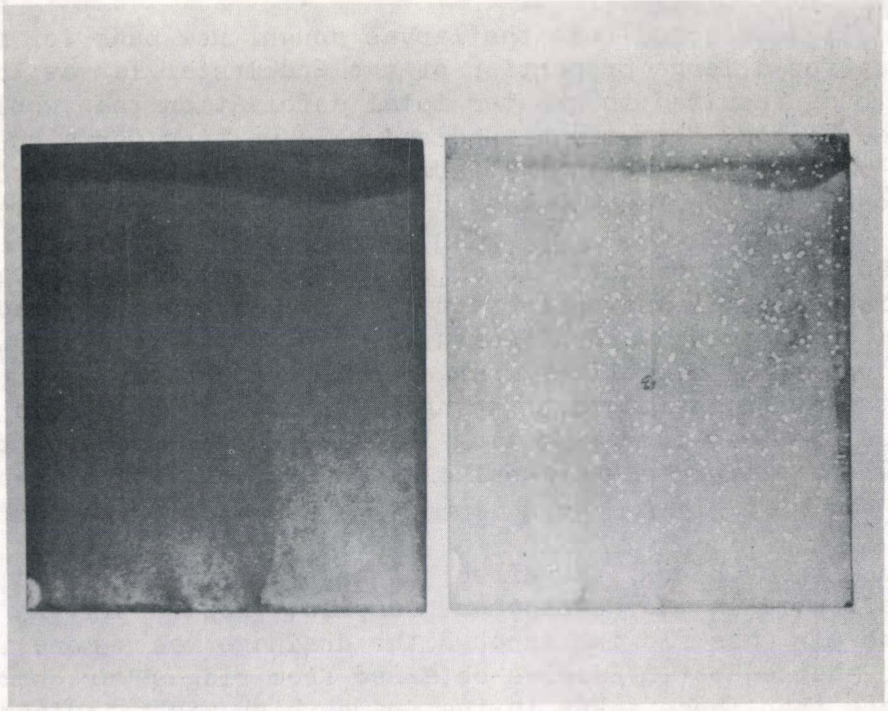


Figure 4.--Spray deposit was sampled by means of cards coated with oil-sensitive dye. The card on the right, used during the 1955 control project, received spray equivalent to 0.4 gal. per acre. The card on left was not exposed to spray.

Although several different types of aircraft were used, the application of spray was found to be satisfactory in most instances. The droplets tended to be rather fine but the size of spray droplets from all types of aircraft were within the specified limits. It was noted that the spray had a slow rate of settling and that lateral movement of the spray clouds took place where the terrain was uneven. It was felt that this resulted in good overlapping of spray swaths and excellent mortality in dense fir stands where the outer foliage would have intercepted coarse spray droplets.

Although the spray was applied by the aircraft at a rate of one gallon per acre, the cards seldom contained evidence of more than 0.2 gallon per acre. Sometimes, as little as 0.01 gallon per acre was visible on the cards. Similar rates of spray recovery have been observed during previous spray projects and in studies involving airplane spraying. However, it was immediately apparent that the amount of spray received by the cards was but one factor which had to be evaluated in assessing the results of spraying. The uniformity of application also seemed very important. As long as the rate of application on the cards was in the neighborhood of 0.1 gallon per acre and

nearly all of an area received coverage, the spraying was satisfactory. The success of spraying was judged best by observation and sampling of larval mortality. The completion of mortality sampling occurred 10 days after an area was sprayed. However, it was not necessary to secure mortality samples where it was desired to merely determine the adequacy of spraying. Whenever a questionable spray-deposit card was encountered, the card checkers noted the abundance of webs and dead larvae in the vicinity. Large numbers of poisoned larvae began descending on their webs within an hour after the spray had been released. A further check on spray deposit was provided by examination of herbaceous foliage surrounding questionable cards. The leaves were burned wherever spray had contacted them.

It was hoped that the cards would not have to be left exposed for more than a day or two, but in practice, they remained on the ground for periods of one to eleven days. Several factors often caused the period of exposure to be longer than planned. Perhaps the most important of these was the time required to spray certain blocks. This, in turn, depended on numerous factors such as size of spray block and output of spray, weather, mechanical trouble, and occasional lag between placement of the cards and start of spraying.

The extended exposure of spray deposit cards created such problems as fading and curling of the cards; also, rodents destroyed or damaged a portion of the cards. Fading was the most common problem. Faded cards were evaluated by wetting them with water or shining ultra-violet light on the cards, which made it possible to see the spray droplets quite well.

Cards[4/] treated with repellent compounds were tested in an attempt to prevent rodent damage. These tests involved regular cards placed side by side with others treated with Goodrich Z-AC and trinitrobenzene (TNB). The test sites were selected from those where rodent damage had been especially severe. Three of each of the three types of card were tested in each of eight locations. Of the 72 cards, 10 suffered rodent damage of some degree. Two of the damaged cards were treated with Z-AC, two with TNB, and six were regular cards. It was concluded that either repellent reduced rodent damage, but over-all damage was also greatly reduced. The presence of the treated cards near the regular cards may have had a general repelling effect.

4/ Provided by the Beltsville Forest Insect Laboratory, Beltsville, Maryland. J. S. Yuill, in Charge.

RESULTS OF CONTROL

Larval mortality was determined by means of population samples taken one day before and 10 days after spraying (fig. 5). A mortality line consisted of 10 sampling stations. The stations were 5 chains apart. One day before spraying began, two 15-inch branches were clipped from each of five trees. All live larvae and pupae on the branches were recorded on Form 4 (Appendix). The second sample was taken 10 days after spraying in order to allow time for the full effect of the DDT to take place. At that time, four 15-inch branches were secured from each of five trees. Again, all live larvae, live pupae, and pupal cases were recorded. The postspray sample base was twice as large as the prespray sample base because the postspray insect population was much reduced. The two samples were adjusted to the same sample base during computation of the percent mortality as follows:

$$\frac{(\text{Prespray count x 2}) - \text{Postspray count}}{(\text{Prespray count x 2})} \text{ x } 100 = \% \text{ mortality}$$

Figure 5. Mortality was determined by comparing the numbers of spruce budworm present on the foliage before and after spraying.

A recapitulation of mortality sampling in 58 spray blocks is contained in table 2. A more detailed account of mortality sampling in each unit will be found in tables 5 to 8. The average mortality as determined from all samples was 95 percent.

Table 2.--Recapitulation of mortality sampling during 1955 Spruce Budworm Control Project in southern Idaho

Unit	No. of sample stations	Population before spraying				Population after spraying			Percent Mortality
		Larvae	Pupae	Total	Total x 2	Larvae	Pupae	Total	
1	149	4,889	0	4,889	9,778	211	162	373	96.2
2	165	4,928	24	4,952	9,904	141	262	403	95.9
3	100	1,713	7	1,720	3,440	76	266	342	90.1
4	155	3,150	5	3,155	6,310	146	204	350	94.5
Total	569	14,680	36	14,716	29,432	574	894	1,468	95.0

The average density of larvae and pupae in the four units before and after spraying is indicated by table 3. The mortality lines were established at random and the population densities were derived from all levels of infestation intensity.

Table 3.--Average prespray and postspray population density in Units 1 to 4

Units	Prespray			Postspray		
	No. 15" branches	Total population	Pop. per 15" branch	No. 15" branches	Total population	Pop. per 15" branch
1	1,490	4,889	3.28	2,980	373	0.13
2	1,650	4,952	3.00	3,300	403	.12
3	1,000	1,720	1.72	2,000	342	.17
4	1,550	3,155	2.04	3,100	350	.11
Total	5,690	14,716	2.59	11,380	1,468	.13

During the project, it was found that mortality lines alone were not satisfactory for determining the need for respraying certain areas. By the time that 10 days had elapsed after spraying, far too many larvae had pupated and respraying would not have been effective. It became evident that mortality lines would have to be supplemented with spray deposit cards or observations of initial mortality if all missed areas were to be detected while they could still be resprayed.

A comparison of the mortality which was obtained by different aircraft is contained in table 4. Except for the Fokker and Fairchild which were checked in only one block each, the upper limits of the

ranges in mortality indicate that each of the aircraft is capable of obtaining excellent mortality. The skill of an individual pilot may be a more important factor than type and size of aircraft. Because of the pilot factor, no attempt should be made to compare the effectiveness of different aircraft. It is felt that, given favorable spray conditions, any of the listed aircraft can bring about satisfactory larval mortality if the pilot covers the area adequately.

Table 4.--Comparison of mortality obtained by different aircraft during 1955 Spruce Budworm Control Project in southern Idaho

Airplane	Unit	No. of blocks	Av. % mortality	Range in mortality
Stearman	2	5	98.5	96.2 - 99.6
Fokker	2	1	96.7	-
B-18	1	15	96.2	89.0 - 100
Ford	2,3,4	18	95.1	83.6 - 100
DC-2, DC-3	4	7	92.8	85.5 - 98.8
TBM	2,3	10	91.9	49.1 - 99.9
Fairchild	2	1	91.3	-
Total	4	57	95.0	49.1 - 100

TECHNICAL ORGANIZATION

The technical organization consisted of 35 men. In addition, from 1 to 6 men were made available in Unit 4 for a 3-week period preceding the start of spraying. These additional men devoted their time to determining the location and extent of new budworm infestations adjacent to the unit.

The total number of personnel and their assignments were as follows:

Technical director	1
Biologist	5
Biologist assistant	3
Insect checker	18
Card checker	8
Additional help (3 weeks)	1-6

One biologist spent part of his time in each of the units and acted as trouble shooter. Generally, he obtained development collections and made observations in remote areas. He also assisted the coordination of activities by taking communications back and forth between the technical director and the other biologists.

The biologists' assistants were employed to classify larval instars contained in development samples after it became apparent that the work load on three of the biologists was too great.

The technical director was the first employee of the technical organization to begin working on the project. His time was devoted to planning many months before weather permitted the start of field work. He assumed residence at the field headquarters at Idaho City on May 14 and was joined soon thereafter by the biologists. The insect checkers were hired on June 1 and the card checkers began work a few days before the first spraying began on July 7.

DISCUSSION AND RECOMMENDATIONS

A natural outgrowth of the experience gained from a large control project is the certain knowledge that some phases of the work could be improved. Although no two undertakings are ever alike, it is perhaps worthwhile to list a number of things which should be taken into consideration in future spruce budworm control projects in southern Idaho. The following recommendations apply to what has been termed the technical side of the project. The author prefers to designate these activities as the entomological aspects of the job.

1. Development samples

Samples should contain only spruce budworm. Other larvae should be segregated by the insect checkers at the time of collection rather than passing this work on to the biologist. Ample recognition aids should be provided all personnel for this purpose.

Transportation of daily collections to the biologist under some circumstances is nearly impossible. The possibility of training some insect checkers to classify the collections and to communicate the information in place of the actual samples should be explored. In conjunction with this, better information pertaining to larval head-width measurements and other means of identifying instars should be obtained.

Because insect development is correlated with altitude, it is especially important that the true elevation of sampling stations be known. The best way to ensure that elevations are accurate is to provide plenty of altimeters to the personnel who establish the sampling stations. It is suggested that as a minimum, one-half of all personnel should have altimeters.

2. Card checking

Of the various activities undertaken by the technical personnel, results of sampling of spray deposit seems to be the most controversial. There are several ways in which the adequacy of spray deposit may be estimated. Actual samples of the spray may be obtained in clearings by such devices as spray deposit cards, glass plates, and herbaceous foliage. Where high larval mortality results, it may be assumed that the spray deposit was satisfactory.

Of these methods, the spray deposit card seems to meet all needs more satisfactorily than the others. Cards are superior to glass plates in that they do not break and can be carried and stored easily. Cards give immediate readings of spray deposit and standard cards containing known rates of application are available for comparison; something which does not exist in the case of herbaceous foliage. In the event that the cards show inadequate spray deposit, observations of foliage and larval mortality should be made in order to determine if the cards were improperly placed.

It is recommended that the cards continue to be used but an effort should be made to improve their resistance to fading and rodent damage.

3. Mortality sampling

Considerable importance is attached to the outcome of mortality sampling. Control projects are judged in large part by the percentage of mortality obtained. Although the method used was satisfactory, some specific things which might be altered to good advantage involve the intensity of mortality sampling and supplementing mortality sampling with spray deposit sampling in the same spray block. Approximately 46 percent of the blocks were sampled for mortality during the 1955 project (most of the remainder were sampled for spray deposit alone). A substantial increase in the percentage of blocks which are sampled for both mortality and spray deposit would be desirable on future projects.

It was thought that mortality sampling in blocks which were not sampled for spray deposit would suffice. This procedure worked all right except in one instance where very low mortality was obtained. The final mortality sample was obtained 10 days after spraying and by then extensive pupation had taken place and it was not possible to respray the block. Had spray deposit cards been used in addition to the mortality sample line, it is likely that the faulty spray deposit would have been discovered in time.

4. Technical organization

It is suggested that two biologists be assigned to each unit. One of the biologists should be administratively in charge and he should be located at a permanent camp with adequate means of communication. His duties should include assigning work to the checkers, maintaining all records of data obtained from his unit, release of spray blocks, and keeping the project entomologist informed of developments. The other biologist should be less burdened and his primary responsibility would be to make detailed observations and to collect development samples in areas where current information may be badly needed. Ordinarily, his efforts would be devoted to back-country areas where overnight trips may be necessary. He should be a very self-reliant person. It is stressed that such personnel are essential in southern Idaho but that they may not be needed in other areas.

During the 1955 project, it became evident that the duties of the insect checkers and card checkers could be combined. This was done in Unit 3. A disadvantage of having a separate position established for spray card checking is that the card checkers arrive on the project just as spraying is about to begin and require training at a time when activities are in high gear. Combining the duties would avoid disruption of the program.

5. New Infestations

Practically every spray project encounters new areas of infestation adjacent to the established control boundary. These infestations usually result from moth flights during the previous year. At present there is no practical way of detecting them before the larvae begin feeding during the spring when the project is under way. Often it is possible to extend the control boundary to include the new infestations, but such action complicates the control program. It would seem that this problem is one requiring research to determine ways of detecting extensions of known damage areas during the same year in which they originate. Perhaps practical survey methods involving moth trapping, egg mass surveys, or sampling of overwintering larvae could be developed. One further step would be to determine the level of population density of new infestations at which control is actually necessary.

6. Timing of control

One of the critical factors that must be considered is the present method of determining the time of spraying in any particular spray block. There is little margin of time allowable, which often makes planning difficult. It is possible that a better means of predicting the initial start of spraying on the project and the time of spraying of each block could be developed. Perhaps predictions might be improved by compiling insect development and weather data for a period of years. Such data should show the expected range and average rate of development in specified situations. Also a day-degree chart might be constructed in order to show the aggregate temperature requirements for particular stages of development. In addition, other phenological studies involving the degree to which insect development and foliage development are correlated should be more fully investigated in Idaho.

7. Records

The job of bringing order out of the chaos of activity on a big control project is at best difficult. Well designed forms for recording data are helpful. Forms such as those included in the appendix proved valuable on the project. The technical director should maintain his own set of forms to record the information received from each biologist.

Copies of the notification of release of spray blocks for spraying should be sent to the technical director at the same time the original is dispatched to the unit supervisor. If it is necessary to phone or radio a release, verification should always follow.

8. Progress reports

Although the material contained in weekly progress reports was often a week old by the time it became distributed, the reports had great value in keeping all personnel informed of the over-all progress. They also served to reflect the situation as it appeared at weekly intervals as the project progressed. Such reports should be a part of every project.

9. Block boundaries

The determination of spray block boundaries is an important undertaking. The manner in which the boundaries are drawn affects many subsequent operations. Unfortunately, good topographic maps and other aids are not always available to help in locating the best boundaries. However, guides have been established which should be considered when block boundaries are being located. These guides are:

a. Boundaries should be located along features which can be seen readily from the air. Ridges are used most commonly but streams are used sometimes. Roads and changes in vegetation type also may be used.

b. The area within blocks should average approximately 4,000 acres. Larger blocks usually have to be split and an excessive period of time is required to spray them. The keeping of records, spray deposit sampling, and mortality sampling are complicated when spraying extends beyond a day or two. Any disadvantages in making spray blocks too small are far less than making them too large. Small blocks may be added together and sprayed at one time more easily than large blocks can be split and sprayed at separate times.

c. Elevational change within any spray block should not exceed 2,000 feet, if possible. Because insect development proved to be sufficiently uniform within elevational changes up to 2,000 feet, adherence to this specification should largely eliminate the need for splitting blocks. Such a restriction in the maximum elevational change within a block may result in the need to use a contour line as a part of a block boundary. While contour lines cannot be seen, it has proved feasible to instruct the pilots to locate such boundaries through reference to their altimeters.

SUMMARY

Between July 7 and August 3, 1955, a large-scale aerial spraying project was undertaken in southern Idaho to control an outbreak of the spruce budworm. The project included 893,212 acres of forest land which were sprayed at a cost of 87 cents per acre. An average of 95 percent mortality was obtained.

The project was administered by National Forest Administration, Region 4. Technical supervision was provided by the Division of Forest Insect Research of the Intermountain Forest and Range Experiment Station. The technical assistance included the sampling of:

1. Insect development in order to determine the correct time of spraying.

2. Spray deposit in order to detect areas which might not be sprayed properly.

3. Larval mortality following the application of spray.

The time of spraying was determined from collections of larvae which were obtained at known elevations daily. Previous experience had shown that the best time for spraying was when the larvae were in the 4th, 5th, and 6th instars. During the course of development sampling, problems involving uneven foliage development, differential rate of larval development on different hosts, and variable weather were encountered. Also, it was noted that the mining of needles by 2nd instar larvae was less common than had been supposed. Larval development was sufficiently uniform throughout 2,000-foot elevational zones but areas covering a greater range in elevation had to be split and sprayed at separate times. A graph (fig. 3) shows the progress of larval development at high and low elevation stations during the project. The rate of larval development lagged as elevation increased.

Spray deposit was sampled by means of cards coated with oil-sensitive dye. The cards were placed in clearings at 5-chain intervals at right angles to the spray swaths. Although the insecticide was applied at the rate of one pound of DDT or one gallon per acre, rates of recovery above 0.2 gallon per acre were not common. However, satisfactory mortality was obtained.

The period during which spray cards were left in the field was longer than planned. Their long exposure caused the dye on the cards to fade and some rodent damage also resulted. Attempts to overcome the rodent damage were made by testing special cards which were treated with repellent compounds. The tests indicated that Goodrich Z-AC and trinitrobenzene were effective in reducing rodent damage.

Larval mortality was determined by comparing postspray populations with population samples taken one day before spraying was undertaken. Ten days were allowed to pass before the postspray samples were taken. The average mortality in 58 spray blocks was 95 percent. Tables are appended which contain summaries of the mortality samples.

A comparison of the mortality obtained by the various types of airplanes used on the project indicated that any of them were capable of obtaining excellent results under favorable conditions.

The technical organization consisted of 35 men. Usually, 1 biologist, 1 biologist's assistant, 4 insect checkers, and 2 card checkers were assigned to each of the 4 units, although some variation existed. It was found that more personnel would be desirable in order to intensify the sampling of insect development, spray deposit, and mortality.

A number of aspects of the control project are discussed and recommendations given. It is believed that the incorporation of recommendations contained in the report should benefit any future aerial spraying project in southern Idaho or similar areas.

Table 5.--Summary of mortality sampling in Unit 1 during 1955 Spruce Budworm Control Project in southern Idaho

Block No.	No. of sample stations	Population before spraying				Population after spraying			Percent mortality	Air-plane
		Larvae	Pupae	Total	Totalx2	Larvae	Pupae	Total		
1	10	226	0	226	452	9	0	9	98.0	B-18
4	10	645	0	645	1,290	76	1	77	94.0	B-18
5	10	553	0	553	1,106	11	0	11	99.0	B-18
6	10	477	0	477	954	11	94	105	89.0	B-18
7	10	295	0	295	590	7	6	13	97.8	B-18
9	10	320	0	320	640	0	0	0	100.0	B-18
10	10	228	0	228	456	1	3	4	99.1	B-18
12	10	377	0	377	754	19	1	20	97.3	B-18
14	10	502	0	502	1,004	0	1/ 56	56	94.4	B-18
15	9	260	0	260	520	0	21	21	96.0	B-18
16	10	203	0	203	406	13	7	20	95.1	B-18
18	10	241	0	241	482	0	2/ 33	33	93.2	B-18
19	10	243	0	243	486	0	2	2	99.6	B-18
21	10	210	0	210	420	0	0	0	100.0	B-18
24	10	109	0	109	218	1	1	2	99.1	B-18
Total	149	4,889	0	4,889	9,778	211	162	373	96.2	

1/ Including 14 pupal cases.

2/ Including 12 pupal cases.

Table 6.--Summary of mortality sampling in Unit 2 during 1955 Spruce Budworm Control Project in southern Idaho

Block No.	No. of sample stations	Population before spraying				Population after spraying			Percent mortality	Air-plane
		Larvae	Pupae	Total	Totalx2	Larvae	Pupae	Total		
1	10	308	0	308	616	4	1/ 12	16	97.4	TBM
4	10	475	0	475	950	3	153	156	83.6	Ford
5	10	374	0	374	748	17	1	18	97.6	Ford
6	10	144	0	144	288	4	5	9	96.9	Stearman
7	6	220	0	220	440	14	0	14	96.8	Ford
10	10	103	0	103	206	9	0	9	95.6	Ford
11	10	236	0	236	472	23	0	23	95.1	Ford
13	10	564	0	564	1,128	13	0	13	98.8	Stearman
15	10	202	0	202	404	0	35	35	91.3	Fairchild
16	10	227	24	251	502	0	19	19	96.2	Stearman
19	10	180	0	180	360	9	3	12	96.7	Fokker
24	10	200	0	200	400	3	1	4	99.0	Stearman
27	10	426	0	426	852	1	0	1	99.9	TBM
29	10	561	0	561	1,122	1	4	5	99.6	Stearman
30	10	194	0	194	388	6	0	6	98.4	TBM
32	9	133	0	133	266	24	10	34	87.2	TBM
36	10	381	0	381	762	10	19	29	96.2	TBM
Total	165	4,928	24	4,952	9,904	141	262	403	95.9	

1/ Including 4 pupal cases.

Table 7.--Summary of mortality sampling in Unit 3 during 1955 Spruce Budworm Control Project in southern Idaho

Block No.	No. of sample stations	Population before spraying				Population after spraying			Percent mortality	Air-plane
		Larvae	Pupae	Total	Totalx2	Larvae	Pupae	Total		
1	10	113	2	115	230	6	111	117	49.1	TBM
2	10	220	0	220	440	5	8	13	97.0	Ford
5	10	226	0	226	452	9	3	12	97.3	TBM
6	10	89	1	90	180	1	1	2	98.9	TBM
8	10	170	1	171	342	39	33	72	78.9	TBM
10	10	141	0	141	282	7	8	15	94.7	Ford
12	10	247	0	247	494	1	15	16	96.8	Ford
15	10	104	0	104	208	2	0	2	99.0	Ford
16	10	138	0	138	276	2	6	8	97.1	Ford
18	10	265	3	268	536	4	81	85	84.1	TBM
Total	100	1,713	7	1,720	3,440	76	266	342	90.1	

Table 8.--Summary of mortality sampling in Unit 4 during 1955 Spruce Budworm Control Project in southern Idaho

Block No.	No. of sample stations	Population before spraying: Larvae	Pupae	Total	Totalx2	Population after spraying: Larvae	Pupae	Total	Percent mortality	Air-plane
2	10	65	0	65	130	1	4	5	96.2	DC-3, Ford
3	10	110	0	110	220	0	2	2	99.1	Ford
10	5	140	0	140	280	23	1/ 2	25	91.1	Ford
12	10	108	0	108	216	2	5	7	96.8	Ford
14	10	269	0	269	538	3	1/ 8	11	98.0	Ford
15 L	10	302	0	302	604	2	1/ 5	7	98.8	DC-2
15 H	10	221	0	221	442	2	1/ 62	64	85.5	DC-2
18	10	162	3	165	330	1	2/ 19	20	93.9	DC-3
20-21	10	591	0	591	1,182	101	3/ 38	139	88.2	DC-3, DC-2
21 L	10	191	0	191	382	1	21	22	94.2	DC-2
21 H	10	410	0	410	820	9	19	28	96.6	DC-2
26	10	160	0	160	320	0	4/ 14	14	95.6	DC-3
28 L	10	91	1	92	184	0	0	0	100.0	Ford
28 H	10	198	0	198	396	1	1	2	99.5	Ford
29	10	113	0	113	226	0	1	1	99.6	Ford
31	10	19	1	20	40	0	4/ 3	3	92.5	Ford
Total	155	3,150	5	3,155	6,310	146	204	350	94.5	

L - Below 6,000" (1st release)
H - Above 6,000" (2nd release)
1/ Including 2 pupal cases
2/ Including 6 " "
3/ Including 1 " "
4/ Including 3 " "

A P P E N D I X

Form 1

SPRUCE BUDWORM LARVAL DEVELOPMENT RECORD

Collector____________________ Collection point No._______

Forest__________________ Unit_________________ Spray block No._________

Collection point location: T.______ R.______ Section______Subdivision______

Elevation_________ Exposure_____________ Topographic position______________

Date block released for spraying_________ Date(s) Block sprayed____________

Date of collection	INSTAR										Pupae		Total No.
	2nd		3rd		4th		5th		6th				
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	

Remarks:

Form 2

Unit No.____

Biologist__________

SPOT CHECKS OF LARVAL DEVELOPMENT

Date	Collector	Elev.	INSTAR										Pupae		Total No. in sample
			2nd		3rd		4th		5th		6th				
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	

Form 3

NOTIFICATION OF RELEASE OF SPRAY BLOCK

The following area is released for spraying on ____________________(date):

Description of area, including priority, spray block number(s), and elevational limits if block must be split:

Priority	Block No.	Elevational limits	Remarks
1.			
2.			
3.			
4.			
5.			
6.			
7.			

Further remarks: ____

____

____

Unless agreed otherwise, the lower elevations should be sprayed first if the period of spraying exceeds one day.

If this is a verification of a release by earlier communication, such release was given by ____________________(name) on __________(date) by the following means of communication: ______________________

(signed) ______________________________
Biologist (or Technical Director)

Date ______________________________

Form 4

SPRUCE BUDWORM MORTALITY RECORD

Forest__________ Control unit__________ Spray block_____ Line No._____

Starting point____________________ Direction run__________

Date released__________ Date(s) sprayed__________ Pilot__________ Plane_____

Sample No.	BEFORE SPRAYING Collector ______ Date ____			AFTER SPRAYING* Collector ______ Date ____			
	Live larvae (No.)	Live pupae (No.)	Total No.	Live larvae (No.)	Live pupae (No.)	Pupal cases (No.)	Total No.
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
Total							

Last development sample before spraying:

2	3	4	5	6	Pupae

*No. of branches examined after spraying will be twice the number examined before spraying.

$$\text{PERCENT MORTALITY} = \frac{\text{Before spray count x 2 - after spray count}}{\text{Before spray count x 2}} \times 100$$

= _____ - _____ = __________ = __________%

Remarks:

Form 5

SUMMARY OF RELEASE OF BLOCKS, PERIOD OF SPRAYING, AND SPRAY DEPOSIT AND MORTALITY SAMPLING

Unit No.________

Biologist______________

								SPRAY CARDS					MORTALITY		
Spray block No.	Spray a.c.	Non-spray a.c.	Total block a.c.	Release order	Date released	Date spraying began	Date spraying ended	Date out	Date in	Adequacy of deposit	Date resprayed	Respray a.c.	Date of prespray count	Date of postspray count	% mort.

Form 6

RECORD OF DAILY SPRAY OUTPUT

Unit No._____

Biologist__________

Date	Sprayed today (gals.)	Cumulative total sprayed (gals.)	Remaining to be sprayed (gals.)	Date	Sprayed today (gals.)	Cumulative total sprayed (gals.)	Remaining to be sprayed (gals.)

Remarks: